DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD.

Curriculum under Choice Based Credit &

Grading System

M.Sc. I & II Year

Statistics

Semester–I to IV

run at college level from the

Academic Year 2015-16 & onwards

Dr. Babasaheb Ambedkar Marathwada University, Aurangabad.

Department of Statistics.

M.A. /M.Sc. (Statistics)

Semester I, II, III and IV

Syllabus

(Choice Based Credit with Grading System) (Under Academic Autonomy of the Department)

W.E.F. June 2011

Syllabus of M.A./M.Sc. (Statistics) Course
(Choice based credit with grading system)
Under Academic Autonomy

The M.A./M.Sc. (Statistics) programme is divided into four semesters with minimum 100 credits comprising of 20 theory courses (80 credits) , 8 practical courses (16 Credits) and a project work (04 credits) .

Eligibility:

Those who have completed B.A./B. Sc. with Statistics / Mathematics as an optional subject from any recognized University/ Institution are eligible for admission. Preference will be given to the candidates who have completed their B.A/B. Sc. with Statistics as one of the optional subject.

Credit System with cafeteria approach:

i)   A candidate who was has successfully completed all the core courses elective / specialized courses and seminars and project prescribed and or optional service courses approved by the University for the Programme with prescribed CGPA shall be eligible to receive the degree.

ii)   One credit shall mean one teaching period of one hour per week for one semester (of 15 weeks) for the theory courses and two practical /laboratory/ field demonstration hours/ week for one semester.

iii)   Every student will have to complete at least 100 credits to obtain the   Master's degree (post graduate degree) in the Statistics subject. out of which 96 credits should be from the Statistics subject (Core course) and four credits from service courses.

Courses

i)   **Core course**: A core course is that a student admitted to particular P.G. programme must successfully complete to receive the degree, normally no theory course shall have more than 4 credits.

ii)   **Elective course:** means a optimal course from the basic subject or specialization.

iii)   **Service course (SC) :** The service courses will be offered in third and fourth semesters in different departments of the university. Student should complete at least one service course in any semester.

iv)   Each course shall include lectures / tutorials / laboratory or field work seminar / a practical training/ Assignments/ midterm and term examination paper, report writing or review of literature and other any innovative practice etc., to meet effective teaching and learning needs.

     v)   Attendance: students must have 75% of attendance in each core and elective courses for appearing the examination. However student having 65% attendance with medical certificate may apply to the H.O.D. for condonation for attendance.

Course Structure

Semester I

Course	Course Title	Teaching time/week	Marks	Credits
STA- 401	Mathematical Analysis	4 hours	100	4
STA- 402	Distribution Theory	4 hours	100	4
STA- 403	Probability Theory	4 hours	100	4
STA- 404	Statistical Inference –I	4 hours	100	4
STA- 405	Statistical Computing	4 hours	100	4
STA- 406	Practical – I	4 hours	50	2
STA- 407	Practical – II	4 hours	50	2
	Total	**---**	**600**	**24**

Semester II

Course	Course Title	Teaching time/week	Marks	Credits
STA- 408	Linear Models	4 hours	100	4
STA- 409	Stochastic Processes	4 hours	100	4
STA- 410	Sample Survey (**Service Course****)	4 hours	100	4
STA- 411	Statistical Inference-II	4 hours	100	4
STA- 412	Regression Analysis	4 hours	100	4
STA- 413	Practical – III	4 hours	50	2
STA- 414	Practical – IV	4 hours	50	2
	Total	**----**	**600**	**24**

Note : ** This course is compulsory for M.Sc. Statistics students.

Semester III

Course	Course Title	Teaching time/week	Marks	Credits
STA- 501	Multivariate Analysis – I (**Compulsory**)	4 hours	100	4
STA- 502	Design & Analysis of Experiment (**Compulsory**)	4 hours	100	4
STA- 503	Operations Research – I (**Compulsory**)	4 hours	100	4
STA- 504	Statistical Methods (**Service Course**)	4 hours	100	4
STA- 505	Industrial Statistics – I (**Elective**)	4 hours	100	4
STA- 506	Actuarial Statistics –I (**Elective**)	4 hours	100	4
STA- 507	Demography (**Elective**)	4 hours	100	4
STA- 508	Econometrics (**Elective**)	4 hours	100	4
STA- 509	Practical – V (**Compulsory**)	4 hours	50	2
STA- 510	Practical – VI (**Compulsory**)	4 hours	50	2
	Total	----	**700***	**28***

Note: ***** Student shall choose any two Electives

Semester IV

Course	Course Title	Teaching time/week	Marks	Credits
STA- 511	Multivariate Analysis – II (**Compulsory**)	4 hours	100	4
STA- 512	Operations Research – II (**Compulsory**)	4 hours	100	4
STA- 513	Industrial Statistics – II (**Elective**)	4 hours	100	4
STA- 514	Actuarial Statistics –II (**Elective**)	4 hours	100	4
STA- 515	Analysis of Clinical Trials (**Elective**)	4 hours	100	4
STA- 516	Time Series Analysis (**Elective**)	4 hours	100	4
STA- 517	Data Mining (**Elective**)	4 hours	100	4
STA- 518	Project (**Compulsory**)	4 hours	100	4
STA- 519	Practical – VII (**Compulsory**)	4 hours	50	2
STA- 520	Practical – VIII (**Compulsory**)	4 hours	50	2
	Total	-----	**600***	**24***

Note: ***** Student shall choose any two Electives

- Students of Sem III shall choose any two electives in consultation with HOD. Combination of electives for SEM III and SEM IV will be as follows.

Sem III	Sem IV
Industrial Statistics – I	Industrial Statistics – II
Actuarial Statistics –I	Actuarial Statistics –II
Demography	Data Mining / Analysis of Clinical trails
Econometrics	Time Series Analysis

- ## Service Courses:

    Following courses will be offered to other department students as service courses (subject to approval by the Departmental Committee).

STA 504   : Statistical Methods : Offered to Sem III Students of other Department.
STA 410 : Sample Survey : Offered to Sem IV Students of other Department .

Notes

- There should not be more than 8 students in a batch for M. Sc. practical course and not more than 5 students in a batch for project course.
- Out of 60 lectures in each theory course about 10 lectures will include tutorials, students seminars and class tests.

STA 518 - Project Work

Carrying out of project is recognized to be the best way of developing the creative & innovative problem solving. It brings forth the students' abilities to cope with real problems of theoretical and practical nature .It helps them to become more proficient in communication skills.

i.   Project work involves field work and live survey
ii.   Students are expected to choose project based on their syllabi
iii. A Project work shall be spread over the semester IV
iv.   Project may be undertaken by a group of maximum 5 students. However they should work independently in consultation with supervisor. Project Report will be submitted by each group separately.

v.   A project work shall be supervised by faculty member assigned by H.O.D
vi.   The project work will be evaluated at the end of semester IV by H.O.D., External Examiner and concerned supervisor.

Evaluation of project work will be based on   (100 marks – 4 credits)

i.   Selection of the topic of project
ii.   Hypothesis and objectives of project
iii.   Reference work related to project
iv.   Research methodology
v.   Data collection
vi.   Statistical Analysis of Data
vii.   Conclusions and suggestions based on data analysis
viii.   Writing and preparation of project report
ix.   Final presentation based on whole project work.
x.   Open Viva- Voce test.

Grade awards

i)   A ten point rating scale shall be used for the evaluation of the performance of the student to provide letter grade for each course and overall grade for the Master's programme. Grade points are based on the total number of marks obtained by him / her in all the heads of examination of the course. These grade points and their equivalent range of marks are shown separately in Table –I

Table I : Ten point grades and grade description

Sr.No	Equivalent %	Grade points	Grade	Grade description
1	90.00 - 100	9.00-10	O	Outstanding
2	80.00 - 89.99	8.00-8.99	A++	Excellent
3	70.00 - 79.99	7.00-7.99	A+	Exceptional
4	60.00 - 69.99	6.00-6.99	A	Very good
5	55.00 - 59.99	5.50-5.99	B+	Good
6	50.00 - 54.99	5.00-5.49	B	Fair
7	45.00 - 49.99	4.50-4.99	C+	Average
8	40.01 - 44.99	4.01-4.49	C	Below average
9	40	4.00	D	Pass
10	< 40	0.00	F	Fail

ii)   Non appearance in any examination / assessment shall be treated as the student have secured zero mark in that subject examination/ assessment
iii)   Minimum D grade (4.00 grade points) shall be the limit to clear / pass the course/ subject. A student with F grade will be considered as failed in the

concerned course and he/ she has to clear the course by preparing in the next successive semester examinations. There will be no revaluation or recounting under this system.

iv) Every student shall be awarded grade points out maximum 10 points in each subject (based on 10 point scale). Based on the grade points obtained in each subject semester grade point average (SGPA) and then cumulative grade point average (CGPA) shall be computed. Results will be announced at the end of each semester and cumulative grade with CGPA will be given on completion of the course.

Computation of SGPA (semester grade point average) & CGPA (cumulative grade point average)

The computation of SGPA & CGPA will be as follows.
a) Semester grade point average (SGPA) is the weighted average of points obtained by a student in a semester and will be computed as follows.

SGPA= Sum (course credits x Number of points in concerned course gained by the student)
                                        Sum (course x credits)

The semester grade point average (SGPA) for all the four semesters will be mentioned at the end of every semester.

b) The cumulative grade point average (CGPA) will be used to describe overall performance of a student in all semesters of the course and will be computed as under.

CGPA= sum (All four semester SGPA)
                Total number of semesters

The SGPA and CGPA shall be rounded off to the second place of decimal

Evaluation method

Each theory course will be of 100 marks and be divided in to internal examination (sessional) of 20 marks and semester end examination of 80 marks. (20+80=100Marks). Each practical course will be of 50 marks. Research project will be of 100 marks.

A :Internal evaluation method

There shall be two mid semester examinations first based on 40 percent syllabus taught and second based on 60 percent syllabus taught. The setting of the question papers and the assessment will be done by concerned teacher who has taught the

course. Average score obtained out of two mid semester examinations will be considered for the preparation of final sessional marks/ grade.

B: Term end examination and evaluation

i) Semester end examination time table will be declared by the departmental committee and accordingly the concerned course teacher will have to set question paper, conduct theory examination , conduct practical examination with external expert, evaluate, satisfy the objection /query of the student (if any) and submit the result to DC.

ii)   The semester end examination theory question paper will have two parts (20+60 = 80) and duration will be 3 hours .

Part A will carry short questions of 2-3 marks (fill in the blanks / multiple choice questions / match columns /state true or false/ answer in one sentence). Part A is compulsory and it is based on entire syllabus (20 Marks).

Part B will carry 7 questions each of 12 marks, (first 5 questions on 5 units and remaining 2 questions on any unit or combination of units). Student will have to attempt any five questions out of 7 (60 Marks).

iii) Semester end practical examinations will be of 50 marks each and students will be examined by one external and one internal examiner. Project work and seminar if any will be evaluated by the external examiners along with guide.

iv) At the end of each semester the committee of department shall assign grades to the students.

v) Every student shall have the right to securitize answer scripts of Mid semester / Term end semester examinations and seek clarifications from the teacher regarding evaluation of the   scripts immediately thereafter or within 3 days of receiving the evaluated scripts.

STA-401 : MATHEMATICAL ANALYSIS

SEM I   **Max Marks : 100**

Credits : 04

Unit-I : Introduction to n dimensional Euclidean space and metric space, system of real numbers, countable and uncountable sets, countability of rational numbers, uncountability of real numbers, supremum and infimum of set of real numbers, interior point, limit point of a set, open set, closed set, dense and compact sets, Bolzano-Weierstrass theorem, Heine-Borel theorem (Statement only), Application of these theorems.   (12 L)

Unit-II : Real valued function, continuity, uniform continuity, power series and radius of convergence , uniform convergence, properties of uniform convergence , Improper integral– definition, general test of convergence, absolute test of convergence, Beta and gamma integral.

(12 L)

Unit-III : Vector space, subspace , linear dependence & independence , basis ,dimension of vector space ,example of vector spaces , algebra of linear transformations. Orthonormal basis and orthogonal projection of vector, Gram–Schmidt orthogonalization process, Kronecker product   (12 L)

Unit-IV : Algebra of matrices, row and column space of matrix, elementary matrices, determinants, rank and inverse of a matrix, null space and nullity, partitioned matrices.   (12 L)

Unit-V : Real quadratic forms, reduction and classification of quadratic forms, index and signature, triangular reduction of a positive definite matrix. Characteristic roots and vectors, Caley – Hamilton theorem and applications , minimal polynomial ,similar matrices, algebraic and geometric multiplicity of a characteristic root, spectral decomposition of real symmetric matrix, reduction of a pair of real symmetric matrices. Hermitian matrices.   (12 L)

Text books :

1) Malik S.A. and Arora S. (1991) : Mathematical Analysis. Wiley Eastern Ltd. 2nd Edn.
2) Deshpande J.V. (1981) : Textbook of Mathematical Analysis. Tata MC-Graw Hill.
3) Rudin Walter (1976) : Principles Mathematical Analysis. Mc- Graw Hill
4) Searle, S.R.(1982) : Matrix algebra useful for statistics.   John Wiley and sons Inc
5) Biswas S.(1984) : Topics in algebra of matrices. Academic publications

Reference Books :
1) Apostoal T.M. (1985) ; Mathematical Analysis. Narosa, Indian Ed.
2) Hadley G.(1987) : Linear Algebra. Narosa Publishing house.
3) Hoffiman K.and Kunze.R. (1971) : Linear algebra. 2nd Ed Prentice hall Inc.

4) Bartle G.R. & Sherbert D.R. (2000) : Introduction to Real analysis. John wiley & Sons.

STA-402: DISTRIBUTION THEORY

SEM: I   **Max Mark: 100**
                                                                              Credit: 04

Unit I: - Basic Distribution Theory: Random experiment and its sample space, events, probability axions, Random variable, Discrete random variables, continuous random variables. Definition of distribution and types of distribution: p.d.f, p.m.f, c.d.f. of random variables, M.g.f, p.g.f., characteristic function of random variables, Moments: raw moments, central moments & factorial moments.   (12L)

 Unit II :- Standard Discrete Distribution : Bernoulli, Binomial, Geometric, Negative binomial, Poisson, Hypergerometric distribution, m.g.f, p.g.f, c.d.f., characteristics function, moments of above discrete distribution, properties of above distribution.   (12L)

Unit III: - Standard Continuous Distribution: Exponential, Normal, Gamma, Beta, Uniform, Lognormal, Weibull, Cauchy, Chi-square,   t-distribution, F-distribution. M.g.f, P.g.f, C.d.f, Characteristics function, moments of above continuous distribution, properties of above distribution.   (12L)

Unit IV:- Joint Marginal and Conditional Distribution : Concept of joint marginal and conditional distribution, variance covariance matrix, joint p.m.f. of discrete r. v., joint p.d.f. of continuous r. v., Bivariate normal distribution, p.d.f., marginal p.d.f., conditional p.d.f., joint m.g.f., properties.   (12L)

Unit V : Inequalities : Markov, Holder, Jonson and Liapuna inequality and its properties .Conditional expectation, Correlation, Multiple and partial correlation, Linear and multiple regressions. Definition of order statistics and their distributions.   (12L)

Text Books
1) Rohtagi V.K. (2003)**:** An introduction to probability theory and mathematical statistics **,**Wiley eastern,   2nd ed.
2) S.C. Gupta and V.K. Kapoor **:-** Fundamental of mathematical Statistics , Sultan Chand company.

Reference Books :-
1) Ash Robert (1972): Real analysis and probability. Academic press.
2) Mukhopadhy .P (1996): Mathematical Statistics, New central book agency,
3) Dudewicz E.J.and Mishra S.N. (1988): Modern Mathematical statistics,
   Wiley Int.   student's Edition.
4) Rao, C.R (1973): Linear Statistical inference and its applications Wiley Eastern.

STA 403 : PROBABILITY THEORY

SEM-I   **Marks : 100**
                                                                                              Credits : 04

Unit-I : Basics of Probability Theory : Axiomatic definition of probability, probability space, independence of two events, mutual independence, sequence of independent events, random variable, expectation of random variable, convergence of sequence of sets, fields and sigma fields, monotone classes, Borel sets in R and R^n, Borel-Cantelli lemma.   (12 L)

Unit-II : Probability Measure : Probability measure on a as sigma field, properties of probability measure, Caratheodory extension theorem (statement only), it's application for the construction of Lebesgue and Lebeasgue-steiltjes measures, measurable functions, borel measurable functins, convergence almost everywhere, convergence in measure.   (12 L)

Unit-III : Convergence in Distribution Function : Distribution function and it's properties, convergence of sequence of random variables, convergence almost sure, convergence in probability, convergence in distribution, convergence in r^{th} mean, inter relations between different types of convergence.   (12 L)

Unit-IV: Law of Large Numbers : Weak law of large numbers (WLLN), Strong law of large numbers (SLLN), Chebyshev's WLLN, Khinchin's WLLN, Kolmogorov's sufficient condition for SLLN, Kolmogorov's SLLN (only statement), Kolmogorov's inequality.   (12 L)

Unit-V: Principles & Theorems based on Central Limit Theorem (CLT) : CLT, Generalization of CLT, Demoivr's, Laplace, Lindeberg-Levy, Lindeberg-Feller (sufficient only) and applications, Liapounov's theorem, Multivariate CLT.   (12 L)

Text Books :

1. Basu, A.K. (1999) : Measure Theory and Probability , Prentic Hall of India.
2. Bhat, B.R. (2000) : Modern Probability Theory, New Age International Pub.
3. Rohatgi V.K. (2003) : An introduction to probability theory and mathematical statistics, Wiley Eastern.

Reference Books :
1. Ast, Robert (1972) : Real Analysis and Probability, Academic Press.
2. Kingman, J.F.C. and Taylor, S.J. (1996) : Introduction to measure and probability, Cambridge University Press.

STA 404 :   STATISTICAL INFERENCE – I

SEM-I   **Marks : 100**
                                                                                   Credits : 04

Unit-I :   Theory of estimation: Introduction, Characteristics of estimators : Unbiasedness, Consistency, Efficiency, Sufficiency. factorization theorem, minimal sufficiency , Minimal Sufficient partition, Construction of Minimal sufficient statistics, special classes of distributions admitting complete sufficient statistics.   (12 L)

Unit-II : Likelihood function, Examples from standard discrete and continuous distributions (such as Bernoulli, Poisson, Negative Binomial, Normal, exponential, Gamma, Pareto etc.), Methods of estimation : Maximum likelihood method, Methods of moments.   (12 L)

Unit-III :, Concept of completeness, bounded completeness, MVUE Uniqueness Rao – Blackwell theorem. Lehmann–scheffs theorem. Application to standard families of distribution Regular families, Fisher information, Cramer Rao inequality.   (12 L)

Unit-IV : Testing of hypothesis : Concept of critical regions, types of hypothesis, test functions, two kinds of errors, level of significance, power function, Neyman- Pearson lemma (with Proof) for test function, MP and UMP test, UMP test for one sided alternative for one parameter exponential class of densities and extension to the distribution having monotone likelihood ratio property.
                                                                                           (12 L)

Unit-V: Interval estimation, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval. Types of scales : Nominal , Ordinal, Interval and Ratio.
Non – parametric tests: Sign test, Run test, Mann- Whitney, Wilcoxon U test, Median test.Kruskal-Wallis Test.   (12 L)

Text Books :
   1) Kale B.K. and Murlidharan.(1999) : A first course on parametric inference,Narosa Publishing House.
   2) Rohatgi V. (1988) :An introduction to Probability and Mathematical Statistics,Wiley Eastern Ltd. New Delhi Student Edition.
   3) Casella G. &beregar R.L.(2002) : Statistical Infefence,2nd edition.
   4) Dudewitz E.J. and Mishra S.N. (1988) : Modern Mathematical Statistics, John Wiley.

Reference Books :
   1) Casella G. And Beregar R. L. (2002) :Statistical Inference,2nd edition, Duxbury Advanced series.
   2) George Casella, Roger L. Berger(2001): Statistical Inference,2nd edition, Duxbury Advanced Press.
   3) Lehmann E.L. (1988) : (latest) Theory of Point Estimation (Student edition),John Wiley.
   4) Lehmann E.L. (1986) :Testing Statistical hypothesis (Student edition),John Wiley.
   5) Rao C.R. (1973) : Linear Statistical Inference and its Application, Wiley series, John Wiley & Sons, Inc.
   6) Dudewicz E.J. and Mishra S.N. (1988): Modern Mathematical statistics, Wiley series in prob. Maths, Statistics, John Wiley and sons New York (Student Edition).
   7) Ferguson T.S. (1967) : Mathematical Statistics, Academic Press.

8) Zacks.S.(1971) : Theory of Statistical Inference, John Wiley and sons, New York.

STA-405 : STATISTICAL COMPUTING

SEM: I   Max.Marks: 100
                                                                                    Credits : 04

Unit-I : Introduction to R- Programming : History of R- Programming, Installation of R-Programming, Starting and ending R, Getting help in R, R Commands and Case Sensitivity, Data Types (Modes), Vector and Vector Arithmetic, Data frames, Various Logical and relational loops, Resident data sets, Using R as calculator.   (12 L)

Unit-II : Descriptive Statistics & Sampling Methods using R-Programming
Classification of Data. Diagrammatic representation of data-Simple & Multiple bar diagram, Subdivided bar diagram, Pie chart, Box Plot, Steam &Leaf plot, Histogram & Frequency Polygon. Measure of Central Tendency- A.M. , G.M. , H.M. , Mode, Median, Partition Values. Measures of Dispersion – Range, Coeff. Of Range, Quartile deviation, Coeff. of Q.D. , Mean deviation , Variance, Standard deviation, Coeff. of variation. Moment.Skewness. Kurtosis, Scatter Plot, Product Moment Correlation Coefficient, Least square regression line, Fit a second degree parabola, Multiple Regression, SRS, Stratified Random Sampling , Systematic Random Sampling , Generations of random numbers.   (12 L)

Unit-III : Probability Distribution and Test of Hypothesis using R-Programming
Problems on finding basic probabilities, Discrete distribution – Binomial distribution,   Poisson distribution, Hypergeometric distribution. Continuous distribution – Normal distribution, Exponential distribution,Large sample test – Proportion test , t-test. Small sample test – t-test, Paired t-test, Chi-square test.   (12 L)

Unit- IV : Experimental Design and Matrix Operations using R-Programming
Completely Randomized Design , Randomized Block Design, Addition , Subtraction and Multiplication. Inverse of matrix, eigen values and eigenvectors .other basic operations.   (12 L)

Unit- V: Overview of SAS , SPSS , SYSTAT and MINITAB
Introduction, Features, Method of data input, Basic statistical operations.   (12 L)

Text Books :

1) Statistics Using R - Sudha G. Purohit, S.D. Gore , S.K. Deshmukh . Narosa Publication.
2) Peter Dalgaard (2008) Introductory Statistics with R, Springer.
3) Michael J. Crawley (2007) The R Book, John Wiley and Sons.

Reference Books :

1) The Art of R Programming - Norman Maltoff
2) W.John Braun, John Braun, Duncan James Murdoch (2007) First
     Course in StatisticalProgramming with R, Cambridge University Press.
3) Maria Dolores Ugarte, Ana F. Militino, Alan T. Arnholt (2008) Probability and Statistics
     with R, CRC Press.

STA-406 : PRACTICAL – I

SEM: I   **Max Mark: 50**
                                                                    Credit: 02

List of practicals (Distribution theory + Stat. inference)

Sr. No.	Title of Practical
1	Fitting of discrete distribution : a) Binomial b) Poisson c) Negative
2	Fitting of continuous distribution : a) Normal b) Exponential c) Lognormal
3	Application of Chi square distribution
4	Application of t distribution
5	Application of F distribution
6	MLE Method
7	Method of Moments
8	Construction of confidence interval
9	UMP Test
10	Nonparametric tests : Sign test, Run test , Mann-Whitney Wilcoxon U test, Median test.

STA-407 : PRACTICAL – II

SEM: I   **Max Mark: 50**
                                                                                   Credit: 02

List of practicals (Mathematical Analysis & Statistical Computing)

Sr. No.	Title of Practical
1	Computation the rank , inverse of Matrix and solving linear equations.
2	Computation of characteristic roots and characteristic vectors of a matrix
3	Reduction of quadric forms to diagonal forms by : i) Orthogonal Method ii) Elementary transformation.
4	Matrix operations using R-Program.
5	R-Programme for Generation of random numbers and SRS.
6	R-Programme for fitting of distribution : i) Binomial Distribution ii) Poisson Distribution iii) Normal Distribution
7	R-Programme for Polynomial Regression Model
8	R-Programme for Testing of Normality using Shapiro-Wilk test
9	R-Programme for Non-Parametric Testing : i) Wilcoxon Signed Rank Test ii) Kruskal-Wallis Test
10	1) R-Programme for Newton Forward method.

STA – 408: LINEAR MODELS

SEM II   **Max Marks: 100**
                                                                                               Credits: 04

Unit I : Linear Model: Definition, conditions of linearity, theory of linear Estimation (theorems based on it), estimation and error functions(theorems based on it), concept of estimability of linear parameter function, generalized inverse, Moore – penrose generalized inverse and all basic properties. Best Linear Unbiased Estimate (BLUE), least square estimation, Gauss Markov theorems, estimation of error variance.   (12L)

Unit II : Analysis of variance (ANOVA): Introduction to design of experiments, need of design of experiments, fundamental principles of design of experiments, contrast, orthogonal contrast, Basic concept of one way and two way ANOVA and classification.   (12L)

Unit III: Basic Designs: Completely Randomized Design (CRD): Layout and randomization, Statistical analysis, Derivation of various formulae, advantage and disadvantages. Randomized Block Design (RBD): Layout and randomization, Statistical analysis, Derivation of various formulae, advantage and disadvantages of RBD over CRD. Latin square Design (LSD): Layout and randomization, Statistical analysis, Derivation of various formulae, advantage and disadvantages of LSD over RBD.   (12L)

Unit IV : Missing values and ANCOVA : Missing plot techniques in RBD and LSD with one missing and two missing observations , ANCOVA for one way and two way classification. Efficiency of RBD related to CRD, Efficiency of LSD related to RBD.   (12L)

Unit V: Estimation & Related Test: Test of hypotheses for one & more than one linear parameter function, Analysis of variance, power of F- test, multiple comparison test due to Tukey, Scheffe simulations confidence intervals.   (12L)

Text Books:-

1) Montgomery D.C. (1991): Design and Analysis of Experiments , John and Wiley
2) Das M.N and Giri (1979): Design and Analysis of Experiments, Eastern Wiley
3) Joshi D.D. (1987): Linear Estimators and Design of Experiments, Wiley eastern
4) Kshirsagar A.M. (1983) : A course in Linear Models. Marcel Dekker Inc New York.

Reference Books:-
1) John P.W.M. (1971): Statistical design and Analysis of Experiments, Macmillan.
2) Giri N. (1986): Analysis of Variance, South Asia publication.
3) Peterson R.G. Design and Analysis of Experiments, Marcel Dekker Inc New York
4) Alok Dey (1986): Theory of Block Design, Eastern Wiley

STA 409 : STOCHASTIC PROCESSES

SEM-II   **Marks : 100**
                                                                              Credits :04

Unit I : Introduction to Stochastic Process : Classification of stochastic processes according to state space and time domain, countable state Markov chains (MC's), Chapman-Kolmogorov equations, calculation of n-step transition probability & its limits, classification of states. Stationary distribution, random walk and gambler's ruin problem, limiting probability, counting process, application from social, biological& physical sciences, statistical inference in Markov chains.   (12 L)

Unit-II : Poisson Process : Properties of Poisson process with results associated with these properties, Generalization of Poisson process, Compound Poisson process.   (12 L)

Unit-III : Birth & Death Process : Continuous time Markov chain, Pure Birth Process, Birth & Death Process, Kolmogorov Backward Equation, Kolmogorov Forward Equation, A machine repair model, Application to queues and storage problem.   (12 L)

Unit-IV : Special case of Stochastic Process and Poisson Process :
Branching Process : Galton-Watson Branching Process, Probability of extinction, distribution of population size. Brownian Motion Process (Wiener Process) : Brownian Motion Process as a limit random walk, problems on standard BMP. Stationary Process : Covariance Stationary, Weakly & Strongly stationary process, Time Series, moving average process, autoregressive Process. Renewal Process : Renewal Reward Process, The average age of a renewal process, the average excess of a renewal process, Regenerate Process, alternating Renewal Process.
                                                                              (12 L)

Unit-V : Continuous Time & Continuous State Space Markov Process :
Kolmogorov-Feller differential equations, Diffusion Processes with wiener process and Orenstein-Uhlenbeck Process as particular cases. First passage time and other problems.   (12 L)

Text Books :
1. Bhat, B.R. (2000) Stochastic Models : Analysis and Applications. New Age International Publications, New Delhi.
2. Medhi, J. (1982) Stochastic Process, Wiley Eastern.
3. Ross, S.M. (2000) Introduction of Probability Models, 7[th]edn. (Academic Press).

Reference Books :
1. Adke, S.R. and Manjunath, S.M. (1984) An Introduction to finite Markov processes. Wiley Eastern.
2. Karlin, S. and Taylor, H.M. (1975) A first course in Stochastic Processes, Vol.1, Academic Press.

STA 410 : SAMPLE SURVEYS

SEM-II   **Marks :100**
                                                                              Credits: 04

Unit-I : Introduction to sampling, review of basic concepts of sampling theory , Population, Sample, Sampling unit, sampling frame, sampling fraction, types of sampling, Random sampling method of selection of random number, etc. Sampling with and without replacement, population parameter ,unbiasedness, Sampling variance, Standard error, efficiency, accuracy and precision. Simple random sampling with and without replacement with estimation of mean and variance.
                                                                              (12 L)

Unit-II : Stratified random sampling: Definition, Principles of stratification, advantages of stratification, Allocation of sample size, methods of allocation like equal samples from each stratum, Proportional allocation, optimum allocation, Neyman allocation. Estimation of mean and variance.
Systematic sampling: Introduction, selection procedure, advantages and disadvantages. Estimation of mean and variance, Comparison of systematic sampling with stratified, Simple and stratified random samples for population with liner trend. Comparison of SRSWOR, with Stratifide random sampling and systematic sampling.
        (12 L)

Unit-III : Cluster sampling: Introduction, notations, advantages, estimation of population mean and variance. Theorem on estimation of sample mean is an unbiased estimator of population mean. Relative efficiency of cluster sampling, estimate mean square between cluster is an unbiased estimate of the mean square between element of the population. Efficiency in terms of intra class correlation coefficient.   (12 L)

Unit-IV : Introduction of PPS sampling. Unequal probability sampling ppswr/ wor methods (including Lahiris scheme) and related estimation of a finite population mean. Order estimates, Desraj's estimators for a general sample size and Desraj's proposed for two samples. Unorder, Murthy's estimator for sampling of size n. Horvitz – Thompson estimator (H- T-E).Murthy's estimator.   (12 L)

Unit-V: Two stage sampling: Introduction, equal first stage units, estimation of population mean and variance. Allocation of sample to the two stage.
Ratio method of estimation : Introduction, estimate mean and variance. Ratio estimate in Stratified sampling.
Regression method of estimation: Introduction, estimate mean and variance. Variance of the simple regression estimate. Comparison of simple regression estimate with the ratio estimate and the simple unbiased estimate. Regression estimates in Stratified sampling.
Randomized response technique (Warner's models).   (12 L)

Text Books :
   1) Sukhatme et al (1984) :Sampling Theory of Surveys with Applications, lowa State University Press and IARS.
   2) Murthy M.N. (1977) : Sampling Theory and Methods, Statistical Publishing .

3) Singh, D. And Choudhary F.S. (1986) Theory and Analysis of Sample Survey Designs, New age International Publishers .Society, Calcutta.
4) Mukhopadhyay P.(1996): Inferential problems in Survey Sampling. New Age International.
5) Cochran, W.G.: Sampling Techniques. (3rd / Edition 1977), Wiley.
6) Des Raj and Chandak (1998) :Sampling Theory, Narosa.

Reference Books :
1) Hedayat A.S. and Sinha B.K.(1991): Design and Inference in Finite Population Sampling. Wiley.
2) Hensen M. M. And Hurwitz W. M. and Mandow W.G.(1954):Sample Survey Methods And Theory, Vol.I and Methods and Applications Vol.II,John Wiley and Sons.
3) Choudhary, A. and Mukerjee, R. (1988) : Randomized Response Theory and Techniques, New York: Marcel Dekker Inc.
4) Gupta S.C. and Kapoor V.K. (2007) :Fundamentals of Applied Statistics,Sultan Chand & Sons, New Delhi.

STA-411 :   STATISTICAL INFERENCE - II

SEM: II   **Max.Marks: 100**
                                                                                          Credits : 04

Unit I : Consistent estimation of real and vector valued parameter. Invariance of consistent estimator under continuous transformation. Consistency of estimators by method of moments and method of percentiles, mean squared error criterion, asymptotic relative efficiency, error probabilities and their rates of convergence, minimum sample size required to attain given level of accuracy.   (12 L)

Unit II : Consistent Asymptotic Normal(CAN) estimator, invariance of CAN estimator under differentiable transformation, CAN property of estimators obtained by moment and MLE method in one parameter exponential family, extension to multiparameter exponential family, examples of consistent but both asymptotically normal estimators from Pitman family.   (12 L)

Unit III : Method of maximum likelihood CAN estimators for one-parameter Cramer family, Cramer-Huzurbazar theorem, Solution of likelihood equations, method of scoring, Newton-Raphson and other interactive procedures, Fisher lower Bound to Asymptotic variance, extension to multiparameter case (without proof) multinomial distribution with cell probabilities depending on a parameter.   (12 L)

Unit IV: MLE in Pitman family and Double Exponential distribution MLE in censored and truncated distributors. Likelihood Ratio Test(LRT), Asymptotic distribution of LRT statistic Wald Test, RAO's Score test , Pearson's chi-square test of Goodness of fit, Bartlett's test for homogeneity of variances.   (12 L)

Unit V: Large sample tests and confidence intervals based on CAN estimators. Variance stabilizing transformation and large sample tests. Consistency of large sample Tests, Asymptotic power of large sample tests.   (12 L)

Text Books:
1) Kale B.K.(1999): A first course on Parametric inference, Narosa Publishing House.
2) Rohatgi V. (1988) :An introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.(Student Edn)
3) Mukhopadhyay P. (1996) :Mathematical Statistics, New Central Book Agency Calcutta.

Reference Books:
1) Lehmann E.L.(1986): Testing Statistical Hypothesis (Student Edition), John Wiley and Sons.
2) Rao C.R.(1973): Linear Statistical Inference, Wiley Series in probability & Statistics
3) Lehmann E.L.(1986): Theory of point Estimation (Student Edition)
4) Dudewicz E.J. and Mishra S.N. (1988): Modern Mathematical Statistics, Wiley Series in Prob. Math. Stat
5) Ferguson T.S (1967): Mathematical Statistics, academic Press
6) Zacks S.(1971) :Theory of Statistical Inference, John Wiley and Sons. New York.

STA-412 : REGRESSION ANALYSIS

SEM II   **Max Mark: 100**
                                                                    Credit: 04

Unit I : Basics of Regression Analysis: Correlation,regression, simple linear regression, and multiple regressions. Variable selection method, fitting of polynomial and use of orthogonal polynomials, coefficient of determination.   (12L)

 Unit II : Residual and Outliers: Residual and their plots as tests for departure from assumptions such as fitness of the model, normally homogeneity of variances and determination of outliers, Robust & L_1 regression, estimation of predication error   by cross validation and boot strap method.   (12L)

Unit III : Non linear Regression: Definition, Non -linear least squares estimation, maximum likelihood estimation, Non -linear least square transformation to a linear model.   (12L)

Unit IV: Generalized linear Model : Logistic regression, analysis of binary and grouped data by using logistic models, log –linear model, test of hypothesis, Wald test, LR test.   (12L)

Unit V: Multicollinearity: Introduction, Ridge regression and ridge trace, principal component regression, Mallow's Cp-statistics.   (12L)

Text book:
1) Monogomery D.C. et al (2003): Introduction to linear regression Analysis.
2) Draper N.R and Smith H (1998): Applied Regression analysis 3rd Ed.wiley.

Reference Books:
1) Weisbers S (1985): Applied linear Regression, Wiley.

2) Cook R.D.F Weisberg S. (1982): Residual & influence in regression, Chapman & hall
3) Gunst N.R .and Mason R.I. (1980): Regression analysis and its
    Applications of Data Oriented Approach, Marcel and Dekker.
4) Rao.C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.

STA-413 : PRACTICAL – III

SEM: II   **Max Mark: 50**
                                                                                Credit: 02

List of practical (Stat.Inf-II, Stochastic Process and Sample survey)

Sr.No.	Title of Practical
1	Method of scoring
2	Wald 's test & Rao Score test
3	Pearson Chi-square test & Bartletts test
4	Construction of transition probability matrix and calculation of n- step transition probabilities.
5	Estimation of mean and variance in SRSWOR/ SRSWR
6	Estimation of mean and variance with unequal probabilities
7	Construction of H- T estimator and estimator variance : a) Lahari's scheme b) Murthy's estimator
8	Estimation of mean and variance in stratified sampling under Neyman – Proportion and optimum allocation.
9	Estimation of mean and variance in : a) Systematic sampling b) Cluster sampling c) Two stage sampling
10	Ratio and regression method of estimation in SRS.

STA-414 : PRACTICAL- IV

SEM:II   Max Mark: 50
                                                                                                                    Credit: 02

List of practical (Linear models + Regression Analysis)

Sr.No.	Title of Practical
1	Analysis of variance in CRD
2	Analysis of variance in RBD
3	Analysis of variance in LSD
4	Analysis of variance in (one) missing plot techniques RBD
5	Analysis of variance in (one) missing plot techniques LSD
6	Analysis of Covariance
7	Fitting of orthogonal polynomials
8	Simple, Partial and multiple correlation
9	Simple, Partial and multiple regression
10	Principal component regression

STA- 501: MULTIVARIATE ANALYSIS –I

SEM: III   **Marks: 100**
                                                                                 Credits: 04

Unit I : Bivariate distribution and multivariate normal distribution (MVND).
Bivariate normal distribution, Bivariate Poisson distribution, Bivariate exponential and Bivariate binomial distribution. Singular and nonsingular multivariate normal distribution. Its moment generating function, characteristic function, conditional distribution and marginal distribution. Distribution of linear combination .   (12L)

Unit II : Quadratic forms of multivariate normal distribution .Central & noncentral chi square distribution, quadratic forms of normal random variables, its distribution, necessary and sufficient condition for a quadratic from to have χ^2 distribution, condition for independence of two quadratic forms, maximum likelihood estimator of parameters of MVND.   (12L)

Unit III : Wishart distribution: Wishart matrix, derivation of Wishart distribution, its characteristic function and properties.   (12L)

Unit IV: Tests of Hypothesis about mean vector of a multivariate normal population. Hotelling's T^2 statistics, its application, likelihood ratio test. Mahalanobis D^2 statistic and its relation with T^2 statistic.   (12L)

Unit V : Partial and multiple correlation coefficients, their properties and sampling distribution.
                                                                                 (12L)

Text Books:
1) Anderson T.W.(1983), Introduction to multivariate analysis (John Wiley)
2) R.A. Johnson, Dean W. Wichern(2002), Applied Multivariate Statistical Analysis.(Prentice hall Inc.)
3) Kshirsagar A.M. (1972), Multivariate Analysis. (Marcel Dekker)

Reference Books:
1) K.C. Bhuyan (2005), Multivariate Analysis and its application, New Central book agency Ltd. Kolkatta
2) C. R. Rao (2002), Linear Statistical Inference and its applications. (Wiley Eastern)
3) Morrison D.F. (1976), Multivariate Statistical Methods. (McGraw Hill)
4) Murihead R.J.(1982), Aspects of Multivariate Statistical Theory (J. Wiley)
5) Seber G.A.F. (1984), Multivariate Observations(Wiley)
6) Sharma S. (1996), Applied multivariate techniques. (Wiley)
7) Srivastva M.S. and Khattri (1979), An introduction to Multivariate Statistics. (North Holland)

STA-502: DESIGN AND ANALYSIS OF EXPERIMENTS

SEM III   **Max. Marks: 100**
                                                                            Credits: 04

Unit I : Factorial experiments: Symmetrical and asymmetrical factorial experiments, Analysis of 2^n and 3^2 factorial experiments. illustrations, estimation of main effects and interactions in 2^2 and 2^3 factorial experiments.   (12 L)

Unit II : Yates method for estimation of factorial effect totals in 2^2 and 2^3 Factorial experiments. Confounding in factorial experiments, complete and partial confounding, Analysis of confounded factorial designs. Fractional replication.   (12 L)

Unit III : Split plot design : What is SPD ? layout and randomization, Statistical analysis of split plot design
Strip plot design: What is Strip plot design? Layout and Randomization, Statistical analysis of strip plot design.   (12 L)

Unit IV : Incomplete Block Designs: Balanced Incomplete Block design (BIBD), General block design and its information matrix, Criteria for Connectedness, Balance and Orthogonally, Construction of Balanced Incomplete Block Designs (BIBD), Relationship among parameters of BIBD, Inter and Intra block analysis of BIBD.   (12 L)

Unit V: Partially Balanced Incomplete Blocks Designs (PBIBD): Relationships among parameter PBIBD. Construction of PBIBD. Concept of Youden Square Design., Galois field, Group of Experiments.   (12 L)

 Text Books:
 1) Das M.N. and Giri N.(1979): Design and Analysis of Experiments, Wiley Eastern.
 2) Montgomery, D.C.(1976) :Design and Analysis of Experiments, Wiley, New York.

References :
1) Aloke Dey (2010): Theory of incomplete Block Designs, Hindustan Book Agency
2) Angels Dean and Daniel Voss (1999): Design and Analysis of Experiments, Springer.
3) Giri N(1986): Analysis of Variance, South Asian publishers.
4) John P.W.M.(1971): Statistical Design and Analysis of Experiments, MacMillan.
5) Joshi D.D.(1987): Linear Estimation and Design of Experiments, Wiley Eastern.
6) Pearce, S.C.(1984) : Design of Experiments , Wiley , New York
7) Rao C.R. and Kleffe J(1988): Estimation of Variance components and applications, North Holland.
 8) Searle S.R., Chella G. and McCullach C.E.(1992): Variance Components, Wiley.

STA- 503 : OPERATIONS RESEARCH – I

SEM. III   **Max marks: 100**
                                                                                       Credits: 04

Unit I : Review of L.P.P., Construction of L.P.P., Simplex method, Big-M method, Two phase method, Revised Simplex method, Definition of dual problem, Relation of dual and primal problem, Duality theorem, Transportation Problem-Definition and Formulation, determination of initial solution, MODI method,   Assignment problem-Definition and Formulation, Hungerian method.   (12L)

Unit II : Nonlinear programming problem: General Nonlinear programming problem, Convex and concave functions, test for concavity and convexity, Lagrange's method for optimality, Kuhn-Tucker condition, Quadratic programming problem-Beals and Wolfes algorithm for solving Q.P.P.   (12L)

Unit III : Inventory Problem: Introduction, Reason for carrying inventory, ABC and VED analysis, JIT concept, EOQ formula of Haris, Inventory models with and without shortages, Inventory models with uniform and instantaneous demand, EOQ formula for single price break, two price break and n price break. Multi item inventory subject to constraint.   (12L)

Unit IV : Probabilistic inventory models: Single period probabilistic inventory model with a) Instantaneous demand and discrete units, b) Instantaneous demand and continuous units, c) continuous demand and discrete units, d) continuous demand and continuous units, (s,S) policy for inventory and its derivation in case of exponential demand, Multi-echelon inventory models, Definition of perishable, different kinds of perishability, Basic inventory model for perishability.   (12L)

Unit V: Sequencing problems: Introduction, Assumption, Processing of n jobs through two machine, Processing of n jobs through three machine, with identical machine sequence for all jobs, Processing of two jobs through m machines.   (12L)

Text books:

1) Hiller and Lieberman Operations Research concepts and cases, Tata macgraw Hill
2) A. Ravindran, D.T. Phillips, J.J. Solberg. (2001) Operations Research Principles   and practices, 2nd ed. John wiley and sons.
3) Taha H.A.(1976) Operations Research, An introduction, 2nd ed.,Macmillan, New york.

References:
1) Sharma J.K (2003) Operations Research theory and application, Macmillan business books.
2) Prem kumar Gupta and D. S Hira Operations Research, S. Chand Publication
3) Hadely G.(1969) Linear programming, Addison Wesley.
4) Wagner H. M. (1975) Principles of Operations Research, 2nd ed. Prentice Hall, Englewood cliffs.

STA-504 : STATISTICAL METHODS

SEM: III   **Max.Marks: 100**
                                                                                       Credits : 04

Unit-I : Statistical Measures : Measures of central tendency : Arithmetic Mean, Geometric Mean, Harmonic Mean, Median and Mode; Measures of Variation : Range, Mean Deviation, Standard Deviation, Coefficient of Variation, Quartiles, Percentiles, Measures of Skewness and Kurtosis. Types of data: Qualitative and Quantitative data. Scale of Measurements (Nominal, Ordinal, Interval and Ratio)   (12 L)

Unit-II : Probability and Distributions: Concept of Probability, Laws of Probability (Statements only); Random Variable; Probability Distributions: Binomial, Poisson and Normal distributions (properties and applications).   (12 L)

Unit-III: Sampling Techniques: Concept and definitions, Types of sampling: Purposive and Random Sampling, Methods of selecting random numbers. Simple Random Sampling, Stratified Random Sampling and Systematic Random Sampling.   (12 L)

 Unit- IV : Test of Significance : Basic concepts; Types of Hypothesis, Types of Error, Critical Region; Large sample tests for proportions and means; small sample tests; Application of t, chi-square, F-tests; Non-Parametric Test : Wilcoxon Signed Rank Test, Median Test and Mann-Whitney U-Test.   (12 L)

Unit-V : Correlation and Regression: Types of Correlation, Simple Correlation, Karl Pearson's Correlation, Multiple Correlation and Partial Correlations, Properties of Correlation Coefficient, Test of Significance of Correlation Coefficient. Regression: Regression Coefficient, Properties of Regression Coefficient, Fitting of Regression Curve (Linear and Non-linear), Multiple Regression, Coefficient of Multiple Determination (R^2), Stepwise/Step down Regression Analysis.   (12 L)

Text Books:
1) Gupta S.C. and Kapoor V.K. (2010): Fundamentals of Mathematical Statistics, Sultan Chand and Sons , New Delhi.
2) Gupta S.P. (2006): Statistical Methods, Sultan Chand and Sons , New Delhi.
3) Rao, C. R. (1973):   Linear Statistical Inference and its Applications , A Wiley – Inter science Publications , JOHN WILEY & SONS, INC.

Reference Books:
1) Gupta S.C. and Kapoor V.K. (2010): Fundamentals of Applied Statistics, Sultan Chand and Sons, New Delhi.
2) Richard B. Ellis(1975): Statistical Inference Basic Concepts, Prentice-Hall, Inc.,
   Englehood Cliffs, New Jersey.
3) E.L. Lehmann (1966): Testing Statistical Hypotheses, New York. John Wiley & Sons, Inc.,London, Sydney.

STA 505 : INDUSTRIAL STATISTICS - I

SEM-III   **Marks : 100**
Credits : 04

Unit-I : Basic concepts of SPC and SQC,: Concept of quality, Quality improvement , quality philosophy . Concept of stable industrial process, Systematic variation, random variation, General theory and review of control charts for attribute and variable data, O.C. and A.R.L. of control charts. Confirming run length(CRL) chart for Attribute.   (12 L)

Unit-II : Moving average and exponentially weighted moving average   (EWMA) charts. CUSUM charts using V – masks and decision intervals Comparison of Shewhart control charts with CUSUM charts. General ideas on economic designing of control charts . Duncan's model for the economic control chart. Process capability and performance indices C_p , C_{pk}, C_{pm}. Estimation and confidence intervals of estimation of C_p .   (12 L)

Unit-III : Acceptance sampling plans for attributes: inspection; Single, Double and multiple sampling plans of attributes and their properties. Operating Characteristic function, concepts of AQL ,LTPD, AOQL average amount of inspection and ASN functions.   (12 L)

Unit-IV :   Acceptance sampling plans for variables: Designing variable acceptance sampling plans . AQL based sampling plans . Continuous sampling plans of Dodge type and Wald – Walfiwitz type and their properties. Problem of lot acceptance - good and bad lots, producer's and consumer's risks chain sampling and sequential sampling plan.   (12 L)

Unit-V: Quality systems : ISO 9000 standards . QS 9000 standards concept of six sigma and define –measure- anlayze – improve – control approach . precision and accuracy in measurement systems . Estimation of measurement uncertainty. Total Quality Management, Taguchi design.
                                                                                        (12 L)

Text Books :
1) Montoegmory, D.C (1985) : Statistical Process Control, John Wiley.
2) Montoegmory, D.C (1985) :Introduction to Statistical Quality Control, Wiley.
3) Logothetis N. (1992) :Managing Total Quality, Prentice Hall of India.
4) Ott E.R. (1975) : Process Quality Control, Mc-Graw Hill.
5) Suddhendu Biswas (2003) : Statistics of Quality Control, New Central Book Agency (P) LTD.
6) Wetherill G.B. and Brown D.W. Statistical Process Control, theory and practice chapman and Hall.

Reference Books :
1) Mahajan M. S. (2005) : Statistical Quality Control. Dhanpat Rai & Co. (P) LTD. Delhi.
2) Phadke, M.S.(1989) : Quality Engineering through Robust Design Pretic Hall.
3) Oakland J.S. (1989) : Total Quality management, Butterworth Heinemann.
4) Mittag H.J. and Rinne.H. (1993) :Statistical process control John Wiley.
5) Wetherill G. B. (1977) : Sampling Inspection and Quality Control, Halsted Press.
6) Mittog H.J. and Rinne H. (1993) :Statistical Methods of Quality Assurance.

7) Oakland J.S. (1989) : Total Quality Management, Butterworth-Heinemann.

STA- 506 : ACTUARIAL STATISTICS – I

SEM: III   **Marks: 100**
                                                                             Credits: 04

Unit I : Introduction to insurance business and Utility theory: Introduction to insurance business, working of insurance business. Utility theory, risk models for short term.   (12 L)

Unit II : Survival function and life tables: Survival function and life tables, assumptions for tractional ages select and ultimate life tables, laws of mortality.   (12 L)

Unit III : Interest: Cash flow models time value of money simple and compound interest. Nominal and effective rates of interest, discounting & accumulating factors, real and money interest rates.   (12 L)

Unit IV: Life insurance: Life insurance, endowment insurance, deferred insurance, benefits payable at the moment of death, benefit payable at the end of year of death.   (12 L)

Unit V: Distribution of aggregate claims: Distribution of aggregate claims compound Poisson distribution and its applications.   (12 L)

Text Books:

1) Deshmukh S.R. (2009), An introduction to Actuarial Statistics Using R (University press)
2) N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. jones and C.J. Nesbit(1986), Actuarial mathematics, Society of Actuaries, Itacasa, IIIinois, U.S.A.
3) Dixit S.P. Modi C.S. & Joshi R.V. (2000) Mathematical basis of life Assurance. Published by Insurance Institute of India, Bombay

Reference Books:

1) Spurgeon E.T. (1972), life Contingencies, Cambridge University Press.
2) Neill A. (1977), life contingencies, Hienemann.
3) Donald D.W.A. (1984), Compound interest & Annuities Certain Published for faculty of Actuaries, and the faculties of actuaries London.
4) McCutcheen J.J.& Scott W.F. (1989) Financial Mathematics, Butterworth Heinemann.

STA 507 : DEMOGRAPHY

SEM III

Max Marks : 100
Credits : 04

Unit-I : Definition and Scope : Development of demography as a interdisciplinary discipline, Basic demographic concept and components of population dynamics. Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan Deming formula to check completeness of registration data. Adjustment of age data. Use of Whipple, Myer and UN indices. Population composition, dependency ratio.   (12 L)

Unit-II : Measure of Fertility : Stochastic models for reproduction, distribution of time to first birth, inter live birth intervals and of number of births (for both homogeneous and non-homogeneous groups of women), estimation of parameters, estimation of parity progression ratios from open birth interval data.   (12 L)

Unit-III : Measure of Mortality : Various measures of mortality, infant mortality rate, cause specific death rate and standardised death rates. Construction of a bridge life table. Distribution of life table functions and their estimation.   (12 L)

Unit-IV : Migration : Migration Rates and Ratios : Indirect measures of net-internal migration. National growth rate method. Stochastic models for migration and for Social and occupational mobility based on Markov chains. Estimation of Measures of Mobility.   (12 L)

Unit-V : Measurement of Population Change : Linear, Geometric, exponential, Gompretz, Logistic Population growth models. Methods of population projection, use of Leslie matrix. Stable and Quasi Stable populations, intrinsic growth rate. Models for population growth and their fitting to population data. Stochastic models for population growth.   (12 L)

Text Books :
 1. Benjamin, B. (1969) : Demographic Analysis, George, Allen & Unwin.
 2. Cox P.R. (1970) : Demography, Cambridge University Press.
Reference Books
 1. Keyfitz N. (1977) : Applied Mathematical Demography, Springer Verlag.
 2. Spiegelman M. (1969) : Introduction to Demographic Analysis, Harvard
    University Press.
 3. Bartholomew D.J. (1982) : Stochastic Models for Social Processes, John
    Wiley.

STA 508 : ECONOMETRICS

SEM III   **Max Marks : 100**
                                                                                 Credits : 04

Unit-I : Nature of Econometrics. The General linear model (GLM) & its extensions. Ordinary least squares (OLS) estimation & prediction. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation & prediction. Heteroscedastic distribution. Pure and mixed estimation. Grouping of observations and of equation.   (12 L)

Unit-II : Auto-correlation, its consequence and tests, the BLUS procedure, Estimation & prediction, Multicollinearity problem,   its implications & tools for handling the problem. Ridge regression.   (12 L)

Unit-III : Linear regression with stochastic regressors, instrumental variable estimation Errors in variables, Autoregressive linear regression. Distributed lag models, use of principal components, canonical and discriminant analysis in econometrics.   (12 L)

Unit-IV : Simultaneous linear equations models. Examples, Identification problem. Restrictions on structural parameters - rank & order conditions. Restrictions on variables and co-variances.
                                                                                   (12 L)

Unit-V : Estimation in simultaneous equations model. Recursive systems, 2 SLS Estimators Limited information estimators, k- class estimators, 3 SLS estimation, Full information maximum likelihood method, Prediction and simultaneous confidence intervals, Monte Carlo studies and simulation.   (12 L)

Text Books :
        1. Chow G.C. (1983), Econometrics, McGraw Hill, New York.
        2. Gujarati D.N. (1995) Basic Econometrics (2nd Ed.) McGraw Hill, New Delhi.
        3. Johnson J. (1991) Econometric Methods, McGraw Hill Book Co. London.

Reference Books
        1.Kennedy. P. (1998), A Guide to Econometrics (4th Ed.) MLT Press. New York.
        2. Kmenta. J. (1997) Elements of Economentrics (Reprint Edition), University of
           Michigan Press, New York.
        3. Koutsoyiannis, A (1977), Theory of Econometrics (2nd Ed) The MacMillan Press Ltd.
           London.
        4. Maddala, G.S. (Ed.) (1993) Econometrics Methods and Application (2Vols),
           Albershot, UK.
        5. Theil, H. (1981) Introduction to Econometrics, Prentics Hall of India New Delhi.

STA 509 : LIST OF PRACTICAL-V

(Multivariate Analysis and D.O.E)

SEM: III   **Max Marks : 50**

1	Estimation of mean vector and variance covariance matrix for multivariate Data
2	Model sampling from multivariate normal distribution
3	Hotelling's T^2 Statistics
4	Analysis of asymmetrical factorial experiments
5	Analysis of factorial experiments (2^2 and 2^3)
6	Analysis of complete and partial confounding
7	Analysis of Split plot design
8	Analysis of Strip plot design
9	Analysis of BIBD
10	Analysis of PBIBD

Credits :02

STA 510 : LIST OF PRACTICAL-VI

SEM: III   **Max Marks :50**
                                                         Credits :02

(Operations Research-I + Actuarial Statistics-I + Industrial Statistics-I)

Sr. No.	Name of the Practical
1	Simplex Method / Dual Simplex Method
2	Big-M or Penalty Method / Two phase method
3	Transportation Problem / Assignment Problem
4	Inventory models- deterministic / price break models
5	Sequencing Problem
6	Construction of Life Tables
7	Actuarial present values of benefit payable at the moment of death
8	Control Chart for variables & Attributes
9	O.C, A.O.Q.L, ASN curves /Process Capability
10	Acceptance sampling plans for Variables & Attributes

STA-511 : MULTIVARIATE ANALYSIS – II

SEM: IV   **Marks: 100**
                                                                                                Credits: 04

Unit I : Regression: Multivariate linear regression, model estimation of parameters and their properties, likelihood ratio test Multivariate analysis of variance (MANOVA) for one way and two way classified data.   (12L)

Unit II : Classification and Discrimination: Classification and discrimination procedures for discrimination between two multivariate normal populations. Sample discriminant function, tests associated with discriminant functions, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations.   (12L)

Unit III : Principal components and Canonical Correlation: Population and sample principal components, derivation of principal components and its properties Canonical correlation coefficients, canonical variates, definition use, estimation and computation.   (12L)

Unit IV: Factor analysis: Orthogonal factor model methods of estimation, factor rotation, factor scores, perspectives for factor analysis.   (12L)

Unit V: Cluster analysis: Similarity measures, hierarchical and non hierarchical clustering methods, correspondence analysis.   (12L)

Text Books:

1) Anderson T.W.(1983), Introduction to multivariate analysis (John Wiley)
2) Richard A. Johnson, Dean W. Wichern(2002), Applied Multivariate Statistical Analysis.(Prentice hall Inc.)
3) Kshirsagar A.M. (1972), Multivariate Analysis. (Marcel Dekker)

Reference Books:

1) K.C. Bhuyan (2005), Multivariate Analysis and its application, New Central book agency Ltd. Kolkatta
2) C. R. Rao (2002), Linear Statistical Inference and its applications. (Wiley Eastern)
3) Morrison D.F. (1976), Multivariate Statistical Methods. (McGraw Hill)
4) Murihead R.J.(1982), Aspects of Multivariate Statistical Theory (J. Wiley)
5) Seber G.A.F. (1984), Multivariate Observations(Wiley)
6) Sharma S. (1996), Applied multivariate techniques. (Wiley)
7) Srivastva M.S. and Khattri (1979), An introduction to Multivariate Statistics. (North Holland)

STA- 512: OPERATIONS RESEARCH – II

SEM. IV   **Max marks: 100**
                                                                          Credits: 04

Unit I : Dynamic programming problem, Optimal decision policy, Dynamic programming under certainty, deterministic and probabilistic, Integer programming problem cutting plane algorithm, branch and bound method.   (12L)

Unit II : Queuing theory: Introduction, Characteristic of system, Probability distribution in queuing system, Steady state solution of M/M/l and M/M/C with associated distribution such as queue length waiting time, and steady state solution of $M/E_k/l$ and M/G/1, Pollaczek-Khintchine formula.   (12L)

Unit III : Game theory : Introduction and assumptions, two person zero sum game, pure and mixed strategies existence of solution and uniqueness of value in zero sum game, Dominance property, Finding solution of 2X2 2xm and mxn games, non –zero sum game equivalence between game theory and L.P.P   (12L)

Unit IV: Replacement models: Introduction,   Types of failures,   Bulk and age replacement, Replacement of equipment fails suddenly, replacement for the equipment deteriorates with time and the value of money a)changes with time, b) does not change with time, Dynamic approach for maintenance problem, **G**roup replacement policy, Replacement of items with long life.   (12L)

Unit V: Networks : Definition, Concept of network, drawing of network, determination of flow's , critical path method and PERT, max flow min cut theorem. Advantages and limitation of networks.   (12L)

Text books :
1) Hiller and Lieberman Operations Research concepts and cases, Tata macgraw Hill
2) A. Ravindran, D.T. Phillips, J.J. Solberg. (2001) Operations Research Principles   and practices, 2nd ed. John wiley and sons.
3) Taha H.A. Operations Research, An introduction, Macmillan, New york.

References :
1) Sharma J.K (2003) Operations Research theory and application, Macmillan business books.
2) Prem kumar Gupta and D. S Hira Operations Research, S. Chand Publication
3) Gross D. and Harris C.M. Fundamentals of queuing theory.
4) Wagner H. M. (1975) Principles of Operations Research, 2nd ed. Prentice Hall, Englewood cliffs.

STA 513 : INDUSTRIAL STATISTICS-II

SEM-IV   **Marks : 100**
                                                                         Credits :04

Unit-I : Forecasting : Concept of forecasting and its application in manufacturing industrial situations, different methods of forecasting : average, least value weighted average (exponential smoothing) forecasting in presence of linear trends using least square methods , forecasting in presence of seasonal effects.   (12 L)

Unit-II : Reliability: Definition and relationship between survival function, hazard function, hazard rate of non –negative random variable, Parametric distribution – Weibull, Gamma, Lognormal and Exponential as life distribution.   (12 L)

Unit-III : Concept of aging, IFR, IFRA classes of distribution and their dual, coherent system as binary   function minimal cut and path sets (vectors), representation of structure function of series, parallel and k out of n.
Systems of independent components. Using minimal cut and path structure functions, derivation of reliabilities of above structures.   (12 L)

Unit-IV : Reliability estimation based on failure times in various censored life tests and in tests with replacement of failed items, stress – strength reliability and its estimation.
Maintenance and replacement policies, availability of repairable systems, modeling of a repairable system by NHPP. Reliability growth models, probability plotting techniques.   (12 L)

Unit-V : Concept of time, order and random censoring, likelihood in these cases Life Distribution : Exponential, Gamma, Weibull, Lognormal distributions. Linear failure rate. Parametric Inference (point estimation, confidence intervals, LR, MLE tests (Rao-Wilks-Wald) for these distributions.
        Life tables, failure rate, mean residual life and their elementary properties. Ageing classes and their properties, Bath tub failure rate. Estimation of survival function. Acturial estimator, Kaplan-Meier estimator, Estimation under the assumption of IFR / DFR.   (12 L)

Text Books :
1) Sinha S.K.(1986): Reliability and Life Testing, Wiley Estern Limited.
2) Suranjan Saha (2006) : Mathematics and Statistics, New Central Book Agency (P) LTD. Kolkata.
3) Barlow R.E. And Proschan F. (1985): Statistical Theory of methods reliability and Life Testing Holt Rinehart and Winston.
4) Lawless J.F. (1982) Statistical Models and methods of life Time Data, John Wiley.
5) Miller R.G. (1981) : Survival Analysis, Wiley.
6) Elandt-Johnson R.E., Johnson N.L. (1980) : Survival Model and Data Analysis, John Wiley and Sons.
7) Cox D. R. And Oaks D. (1984) : Analysis of Survival data, Chapman and Hall.

Reference Books :
1) Bain L.J. And Engethaardt (1991): Statistical Analysis of Reliability and Life Testing models Marcel Derkker.
2) Montegom -ery D.C.(1996): Introduction to Statistical Quality Control, Wiley.
3) Nelson W.(1982) : Applied Life Data Analysis John Wiley.
4) Zacks S. (1992) :Introduction to reliability analysis Probability Models and statistical Methods Springer verlag.
5) Mahajan M. S. (2005) : Statistical Quality Control. Dhanpat Rai & Co. (P) LTD.
6) Barlow R.E. and Proschan F. (1985) : Statistical Theory of Reliability and Life Testing, Rinehart and Winston.

STA-514 : ACTUARIAL STATISTICS – II

SEM: IV   **Marks: 100**
                                                                                                 Credits: 04

Unit I : Annuities: Continuous life annuities, discrete life annuities, life annuities with monthly payments, apportionable annuities.   (12L)

Unit II : Premiums: Fully continuous & discrete premiums, mthly payment premiums apportionable premiums.   (12L)

Unit III: Reserve: Prospective & retrospective reserve, fully continuous and discrete reserve, reserves on an apportionable or discounted continuous basis.
                                                                                                 (12L)
Unit IV: Multiple life functions: Joint life status, last survivor status, insurance and annuity benefits through multiple life functions, evaluation for special mortality laws. Deterministic and random survivorship groups associated single decrement tables, central rates of multiple decrements, net single premium and their numerical evaluations.   (12L)

Unit V : Investments and project appraisal: Equations of value, loan schedules project appraisal, investments, arbitrage & forward contacts, term structure of interest rates, stochastic interest rate models.   (12L)

Text Books:
1) Deshmukh S.R. (2009): An introduction to Actuarial Statistics Using R(University press)
2) N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbit(1986): Actuarial mathematics, Society of Actuaries, Itacasa, IIIinois, U.S.A.

Reference Books:
1) Spurgeon E.T. (1972): life Contingencies, Cambridge University Press.
2) Neill A. (1977): life contingencies, Hienemann.

STA 515 : ANALYSIS OF CLINICAL TRIALS

SEM-IV   **Marks : 100**
Credit : 04

Unit I : Introduction to clinical trials : The need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trails.   (12 L)

Unit II : Data Management : data definitions, case report forms, database design, data collection system for good clinical practice.   (12 L)

Unit III : Design of clinical trials : Parallel vs cross-over designs, cross-sectional design vs longitudinal designs, review of factorial designs, objectives and end points of clinical trials, design of Phase I trials, Design of single-stage and multi-stage Phase II trials, design and monitoring of Phase-II trials with sequential stopping, design of bio-equivalence trials.   (12 L)

Unit IV : Reporting and analysis : Analysis of categorical outcomes from Phase I-III trials, analysis of survival data from clinical trials, Interim analysis, motivating intent-to-treat analysis, Determining sample size.   (12 L)

Unit V : Surrogate endpoints : Selection and design of trails with surrogate endpoint data, analysis of surrogate endpoint data, Meta-analysis of clinical trials.   (12 L)

Text Books:
1. S.Piantadosi (1997) Clinical Trails : A methodological Perspective. Wiley and Sons.
2. L.M. Friedman, C.Furburg, D.L. Demets (1998) Fundamentals of Clinical Trials, Springer Verlag.
3. J.L. Fleiss (1989). The design and Analysis of Clinical Experiments. Wiley and Sons.
4. Daowen Zhang (2009) Statistical Principles of Clinical Trials (Lecture Notes).

Reference Books :
1. C.Jennison and B.W. Turnbull (1999). Group sequential methods with application to Clinical Trails, CRC Press.
2. E.Marubeni and M.G. Valsecchi (1994) Analyzing Survival Data Clinical Trails and Observational Studies, Wiley and Sons.

STA 516 : TIME SERIES ANALYSIS

SEM IV   **Max Marks : 100**
                                                                          Credits   : 04

Unit-I: Time series as discrete parameter stochastic process.
Features of time series Data :Trend, Seasonality, auto covariance and auto correlation function and their properties, Two exploratory time – series analysis   (12 L)

Unit-II: Test for randomness of a series against trend and seasonality M.A and exponential smoothing, Hot winters smoothing, forecasting based on smoothing, adaptive smoothing.
                                                                          (12 L)

Unit-III: Study of stationary process – (a)moving average (M.A), (b)auto regressive (AR), (c)ARMA and (d)ARIMA model box – Jenkins model   Discussion (without proof) of estimation of means, auto covariance and auto correlation function under large sample theory.
Choice of AR and MA periods.
Estimation of ARIMA model parameters.
Forecasting, residual analysis and diagnostic checking.   (12 L)

Unit-IV: Introduction to spectral analysis of weekly stationary process.
Periodogram and correlogram analysis.   (12 L)

 Unit-V: Non – stationary and seasonal time models :Unit – root non –stationarits, unit– root test, integrated ARMA (ARIMA) models seasonal ARIMA (SARIMA) models.   (12 L)

Text Books :
1. Anderson T.W :The statistical analysis of time series, Wiley.
2. Montgomery DC and Johnson LA :Forecasting and time series analysis, Mcgrew Hill.

Reference Books
1. Kendall and Ord :Time series (3rd Edition), Edward Arnold.
2. Brockwell P.J and Daris R.A :Time series : Theory and methods springer – verlag.
3. Box G.E.P and Jenkins G.M :Time series analysis – forecasting and control, holdan – day, san Francisco.

STA 517 : DATA MINING

SEM-IV   **Marks : 100**
                                                                      Credits :04

Unit I : Review of classification methods from multivariate analysis classification and decision trees   (12L)

Unit II : Clustering methods for both statistical and data mining viewpoints vector quantization
                                                                      (12 L)

Unit III : Unsupervised learning from unvariate and multivariate data . Dimension reduction and feature selection.   (12L)

Unit IV   : Supervised learning from moderate to high dimensional input spaces artificial neural networks and extensions of regression models trees.   (12L)

Unit V : Introduction to databases including simple relational databases, data warehouses and introduction to online analytical data processing. Association rules and predication data attributes, applications to electronic commerce.   (12L)

Text Books
1) Berson   A. and smith S.J. (1997) Data warehousing, Data mining and OLAP (McGraw- Hill)
2) Breiman L, Friedman J.H. Olshen R.A. And stone C.J. (1984) classification and regression trees. (wadsworth and brooks /cole)
3) Han J and Kamber M (2000) Data mining concepts and techniques (Morgan Kaufmann)

 Reference Books :
1) Mitchell T.M. (1997) Machine learning (McGraw- Hill)
2) Ripley B.D. (1996) Pattern Recognition and neural Networks (Cambridge University Press)

SEM IV: STA 518 - Project   (100 Marks - 04 Credits)

i.   Statistical Analysis of Data
ii.   Conclusions and suggestions based on data analysis
iii.   Writing and preparation of project report
iv.   Final presentation based on whole project.

STA 519 : LIST OF PRACTICAL-VII

(Multivariate Analysis-II and Operations Research-II)

SEM: IV   **Max Marks :50**

Credits :02

1	Multivariate linear regression
2	Multivariate analysis of variance (MANOVA)
3	Classification & Discrimination problem
4	Principal components
5	Canonical correlation
6	Integer programming problem
7	Queuing theory
8	Game theory
9	Replacement problem
10	Network problem – PERT/CPM

STA 520 : LIST OF PRACTICAL-VIII

SEM: IV   **Max Marks :50**

Credits :02

(Actuarial Statistics-II + Industrial Statistics-II)

1	Computation of Premiums

2	Benefit payable at end of year of death
3	Discrete life Annuities
4	Continuous life Annuities
5	Computation of Reserves
6	Ratio to moving Average Method
7	Link Relative Method
8	Ratio to Trend Method
9	Exponential Smoothing method
10	Measurement of Reliability (Series and Parallel)